CLAIMS

1. An apparatus for monitoring conditioning of a planarizing medium used for planarizing a microelectronic substrate, comprising:

a conditioning body having a conditioning surface configured to engage a planarizing surface of the planarizing medium, at least one of the conditioning body and the planarizing medium being movable relative to the other of the conditioning body and the planarizing medium to condition the planarizing surface; and

a sensor coupled to the conditioning body to detect a frictional force in a plane of the planarizing surface, the frictional force being imparted to the conditioning body by the planarizing medium when the one of the conditioning body and the planarizing medium is moved relative to the other of the conditioning body and the planarizing medium.

2. The apparatus of claim 1 wherein the planarizing medium includes a polishing pad.

3. The apparatus of claim 1 wherein the conditioning body has a conditioning surface generally parallel to the planarizing surface.

4. The apparatus of claim 1 wherein the conditioning body includes abrasive elements for abrading the planarizing surface of the planarizing medium.

5. The apparatus of claim 1, further comprising a support member coupled to the conditioning body, further wherein the sensor includes a strain gauge connected to the support member to detect a deflection of the support member resulting from the force on the conditioning body.

6. The apparatus of claim 1, further comprising:

a first support member having first and second ends and being rotatably coupled toward the first end to the conditioning body, the second end of the first support member extending away from the conditioning body; and

a second support member coupled at a pivotable coupling to the first support member toward the second end of the first support member, the sensor being positioned between the first and second support members, the first support member being pivotable relative to the second support member to transmit a force to the sensor corresponding to the frictional force.

7. The apparatus of claim 1 wherein the sensor includes a force sensor.

8. The apparatus of claim 1 wherein the sensor includes a strain gauge.

9. The apparatus of claim 1, further comprising an electric actuator coupled to the conditioning body to rotate the conditioning body relative to the polishing pad, wherein the sensor includes a current sensor coupled to the actuator to detect an electric current drawn by the actuator.

10. The apparatus of claim 1, further comprising an actuator coupled to the conditioning body for controlling at least one of a position of the conditioning body and an approximately normal force between the conditioning body and the planarizing medium, the actuator being coupled to the sensor to receive signals from the sensor and adjust the one of the position and the approximately normal force in response to the signal.

11. The apparatus of claim 1, further comprising:

a piston; and

a cylinder having an open end and a closed end, the cylinder sealably and slidably receiving the piston, at least one of the piston and the cylinder being coupled to the conditioning body to slide relative to the other of the piston and the cylinder under the influence of the frictional force on the conditioning body, the piston and the cylinder defining a sealed gap between an end of the piston and the closed end of the cylinder, the sensor being positioned within the gap for measuring a change in pressure within the gap as the piston moves relative to the cylinder.

12. The apparatus of claim 11 wherein the piston has a generally circular cross-sectional shape and the cylinder has an aperture with a generally circular cross-sectional shape for receiving the piston.

13. The apparatus of claim 11 wherein the piston has a generally rectangular cross-sectional shape and the cylinder has an aperture with a generally rectangular cross-sectional shape for receiving the piston.

14. The apparatus of claim 1, further comprising:

a piston; and

a cylinder having an open end and a closed end, the cylinder slidably receiving the piston, at least one of the piston and the cylinder being coupled to the conditioning body to slide relative to the other of the piston and the cylinder under the influence of the frictional force on the conditioning body, the piston and the cylinder defining a gap between an end of the piston and the closed end of the cylinder, the sensor including a gauge positioned to measure movement of the one of the piston and the cylinder relative to the other of the piston and the cylinder.

15. The apparatus of claim 14 wherein the piston is sealably engaged with the cylinder.

16. The apparatus of claim 14, further comprising a biasing member coupled to the cylinder and the piston to bias the piston toward or away from the cylinder.

17. The apparatus of claim 14 wherein the gauge includes a pointer on one of the piston and the cylinder and a scale on the other of the piston and the cylinder, the pointer being aligned with the scale and movable relative to the scale to indicate relative movement between the piston and the cylinder.

18. The apparatus of claim 1 wherein the planarizing medium includes a polishing pad elongated to form a continuous loop extending over at least two rollers, further wherein the conditioning body extends transverse to the polishing pad.

19. The apparatus of claim 18 wherein the conditioning body is generally rigid, further comprising an actuator coupled to the conditioning body to control a force between the conditioning body and the polishing pad.

20. The apparatus of claim 18 wherein the conditioning body is at least partially compliant in a direction approximately normal to the polishing pad, further comprising a plurality of actuators coupled to the conditioning body, each actuator configured to control a normal force between the polishing pad and a portion of the conditioning body.

21. The apparatus of claim 1 wherein the conditioning body has a generally circular planform shape.

22. An apparatus for measuring forces during conditioning of a chemical-mechanical planarizing surface, comprising:

a planarizing medium having a planarizing surface for removing material from a microelectronic substrate, the planarizing surface defining a planarizing surface plane;

a conditioning body adjacent to the planarizing medium, at least one of the conditioning body and the planarizing medium being movable relative to the other of the conditioning body and the planarizing medium for conditioning the planarizing surface, the conditioning body and the planarizing medium generating a force in the planarizing surface plane when the one of the conditioning body and the planarizing medium moves relative to the other of the conditioning body and the planarizing medium; and

a sensor operatively coupled to the conditioning body to detect the force.

23. The apparatus of claim 22 wherein the planarizing medium includes a polishing pad.

24. The apparatus of claim 22 wherein the conditioning body has a conditioning surface generally parallel to the planarizing surface.

25. The apparatus of claim 22 wherein the conditioning body is rotatable relative to the planarizing medium.

26. The apparatus of claim 22 wherein the conditioning body is translatable relative to the planarizing medium.

27. The apparatus of claim 22 wherein the planarizing medium is rotatable relative to the conditioning body.

28. The apparatus of claim 22 wherein the force is a drag force, further comprising:

a first support member having first and second ends and being rotatably coupled toward the first end to the conditioning body, the second end of the first support member extending away from the conditioning body; and

a second support member coupled at a pivotable coupling to the first support member toward the second end of the first support member, the sensor being positioned between the first and second support members, the first support member being pivotable relative to the second support member to transmit a force to the sensor corresponding to the drag force.

29. The apparatus of claim 22 wherein the sensor includes a force sensor.

30. The apparatus of claim 22 wherein the sensor includes a strain gauge.

31. The apparatus of claim 22, further comprising:

a piston; and

a cylinder having an open end and a closed end, the cylinder slidably receiving the piston, at least one of the piston and the cylinder being coupled to the conditioning body to slide relative to the other of the piston and the cylinder under the influence of the force on the conditioning body, the piston and the cylinder defining a gap between an end of the piston and the closed end of the cylinder, the force sensor including a gauge positioned to measure movement of the piston relative to the cylinder.

32. The apparatus of claim 31 wherein the piston is sealably engaged with the cylinder.

33. The apparatus of claim 31, further comprising a biasing member coupled to the cylinder and the piston to bias the piston toward or away from the cylinder.

34. The apparatus of claim 22, further comprising a feedback device coupled to the sensor and the conditioning body for changing at least one of the force between the conditioning body and the polishing pad and a position of the conditioning body relative to the polishing pad in response to a signal from the sensor.

35. An apparatus for monitoring conditioning of a planarizing medium used for chemical-mechanical planarization of a microelectronic substrate, comprising:

a conditioning body having a conditioning surface configured to engage a planarizing surface of the planarizing medium, at least one of the conditioning body and the planarizing medium being movable relative to the other of the conditioning body and the planarizing medium to condition the planarizing surface, the conditioning body generating a drag force generally parallel to the planarizing surface;

an actuator coupled to the conditioning body with a support assembly to control at least one of a generally normal force between the conditioning body and the planarizing medium and a position of the conditioning body relative to the planarizing medium;

a sensor coupled to the support assembly to detect the drag force; and

a feedback device coupled to the actuator to control activation of the actuator in response to a signal received from the force sensor.

36. The apparatus of claim 35 wherein the feedback device includes a microprocessor.

37. The apparatus of claim 35 wherein the actuator is positioned to move the conditioning body laterally over the planarizing surface.

38. The apparatus of claim 35 wherein the actuator is positioned to rotate the conditioning body in a generally circular motion over the planarizing surface.

39. The apparatus of claim 35 wherein the planarizing medium includes a polishing pad.

40. The apparatus of claim 35, further comprising:

a first support member having first and second ends and being rotatably coupled toward the first end to the conditioning body, the second end of the first support member extending away from the conditioning body; and

a second support member coupled at a pivotable coupling to the first support member toward the second end of the first support member, the sensor being positioned between the first and second support members, the first support member being pivotable relative to the second support member to transmit a force to the sensor corresponding to the drag force.

41. The apparatus of claim 35 wherein the sensor includes a force sensor.

42. The apparatus of claim 35 wherein the sensor includes a strain gauge.

43. The apparatus of claim 35, further comprising:

a piston; and

a cylinder having an open end and a closed end, the cylinder slidably receiving the piston, at least one of the piston and the cylinder being coupled to the conditioning body to slide relative to the other of the piston and the cylinder under the influence of the force on the conditioning body, the piston and the cylinder defining a

gap between an end of the piston and the closed end of the cylinder, the sensor being positioned to detect relative motion between the piston and the cylinder.

44. The apparatus of claim 43 wherein the piston is sealably engaged with the cylinder and the sensor includes a pressure gauge positioned within the gap to detect a change in pressure in the gap when one of the piston and the cylinder moves relative to the other.

45. The apparatus of claim 43, further comprising a biasing member coupled to the cylinder and the piston to bias the piston toward or away from the cylinder.

46. A method for monitoring conditioning of a planarizing medium used for planarizing a microelectronic substrate, comprising:

moving at least one of the planarizing medium and a conditioning body relative to the other of the planarizing medium and the conditioning body while the conditioning body is engaged with a planarizing surface of the planarizing medium; and

monitoring the conditioning body to detect a force of the planarizing medium on the conditioning body.

47. The method of claim 46 wherein monitoring the conditioning body includes detecting a frictional force on the conditioning body in a plane generally parallel to a plane of the planarizing surface.

48. The method of claim 46 wherein moving at least one of the conditioning body and the planarizing medium includes rotating the conditioning body relative to the planarizing medium with an electric motor, further wherein detecting the force includes detecting an electrical current drawn by the motor.

49. The method of claim 46 wherein moving at least one of the conditioning body and the planarizing medium includes rotating the planarizing medium relative to the conditioning body.

50. The method of claim 46 wherein the conditioning body is coupled to a support member for supporting the conditioning body relative to the planarizing medium, further wherein monitoring the conditioning body includes measuring a force transmitted to the support member by the conditioning body.

51. The method of claim 50 wherein the support member includes a generally upwardly extending portion coupled to the conditioning body and a generally laterally extending portion pivotably coupled to the upwardly extending portion, further wherein monitoring the conditioning body includes detecting a force between the upwardly extending portion and the laterally extending portion with a force sensor.

52. The method of claim 50 wherein monitoring the conditioning body includes detecting a deflection of the support member.

53. The method of claim 50 wherein the support member includes a piston slidably received in a cylinder and monitoring the conditioning body includes detecting a movement of one of the piston and the cylinder relative to the other of the piston and the cylinder.

54. The method of claim 53, further comprising biasing one of the piston and the cylinder toward or away from the other of the piston and the cylinder.

55. The method of claim 50 wherein the support member includes a piston slidably and sealably received in a cylinder to form a sealed space between an end of the cylinder and an end of the piston, further wherein monitoring the conditioning body includes detecting a pressure within the sealed space.

56. The method of claim 46 wherein moving at least one of the conditioning body and the planarizing medium relative to the other of the conditioning body and the planarizing medium includes sweeping the conditioning body laterally over the planarizing surface of the planarizing medium while rotating the planarizing medium relative to the conditioning body.

57. The method of claim 46, further comprising removing material from the planarizing medium while at least one of the conditioning body and the planarizing medium moves relative to the other of the conditioning body and the planarizing medium.

58. The method of claim 46, further comprising adjusting a force applied to the conditioning body approximately normal to the planarizing surface in response to detecting a force of the planarizing medium on the conditioning body.

59. The method of claim 46 wherein moving at least one of the planarizing medium and the conditioning body includes rotating the planarizing medium at a variable rate as the conditioning body moves across the planarizing medium to maintain a relative velocity between the planarizing medium and the conditioning body at an approximately constant value.

60. A method for monitoring conditioning of a planarizing medium used for planarizing a microelectronic substrate, the method comprising:

coupling a sensor to a conditioning body;

engaging the conditioning body with the planarizing medium and moving at least one of the conditioning body and the planarizing medium relative to the other of the conditioning body and the planarizing medium while the conditioning body engages the planarizing medium; and

monitoring the conditioning body to detect a frictional force between the conditioning body and the planarizing medium.

61. The method of claim 60 wherein moving at least one of the conditioning body and the planarizing medium includes rotating the conditioning body relative to the planarizing medium with an electric motor, further wherein detecting the frictional force includes detecting an electric current drawn by the motor.

62. The method of claim 60 wherein the conditioning body is coupled to a support member for supporting the conditioning body relative to the planarizing medium, further wherein monitoring the conditioning body includes measuring a force transmitted to the support member by the conditioning body.

63. The method of claim 62 wherein monitoring the conditioning body includes detecting a deflection of the support member.

64. The method of claim 62 wherein the support member includes a piston slidably received in a cylinder and monitoring the conditioning body includes detecting a movement of one of the piston and the cylinder relative to the other of the piston and the cylinder.

65. The method of claim 62 wherein the support member includes a piston slidably and sealably received in a cylinder to form a sealed space between an end of the cylinder and an end of the piston, further wherein monitoring the conditioning body includes detecting a pressure within the sealed space.

66. The method of claim 60 wherein the planarizing medium includes a polishing pad and moving at least one of the planarizing medium and the conditioning body relative to the other of the planarizing medium and the conditioning body includes rotating the polishing pad relative to the conditioning body.

67. A method for controlling conditioning of a planarizing medium used for planarizing a microelectronic substrate, the method comprising:

engaging a conditioning body with the planarizing medium and moving at least one of the conditioning body and the planarizing medium relative to the other of the conditioning body and the planarizing medium while the conditioning body engages the planarizing medium;

detecting a frictional force between the conditioning body and the planarizing medium; and

controlling at least one of a force between the conditioning body and the planarizing medium and a speed of the conditioning body relative to the planarizing medium in response to detecting the frictional force between the conditioning body and the planarizing medium.

68. The method of claim 67 wherein controlling a force between the conditioning body and the planarizing medium includes receiving a force signal from a force sensor and transmitting a command signal to an actuator coupled to the conditioning body.

69. The method of claim 68 wherein receiving the force signal includes receiving the force signal with a microprocessor and transmitting a command signal includes transmitting the command signal from the microprocessor.

70. The method of claim 67 wherein controlling a force includes adjusting a force on the conditioning body that is approximately normal to a planarizing surface of the planarizing medium.

71. The method of claim 67 wherein the planarizing medium includes a polishing pad and moving at least one of the conditioning body and the planarizing medium relative to the other of the conditioning body and the planarizing medium includes rotating the polishing pad relative to the conditioning body.

72. The method of claim 67 wherein controlling a speed of the conditioning body relative to the planarizing medium includes moving the conditioning body radially relative to the planarizing medium.

73. The method of claim 68 wherein controlling a speed of the conditioning body includes rotating at least one of the conditioning body and the planarizing medium relative to the other about an axis generally normal to the planarizing medium.

74. A method for monitoring a polishing pad used for planarizing a microelectronic substrate, the method comprising:

engaging a conditioning body with a planarizing surface of the polishing pad;

applying a force to the polishing pad via the conditioning body;

moving at least one of the polishing pad and the conditioning body relative to the other of the polishing pad and the conditioning body; and

detecting a frictional force of the polishing pad on the conditioning body in a plane of the planarizing surface.

75. The method of claim 74 wherein applying a force includes applying a force to the conditioning body different than a weight of the conditioning body.

76. The method of claim 74 wherein the force is a first force, further comprising conditioning the polishing pad by applying a second force to the conditioner greater than the first force to remove material from the planarizing surface of the polishing pad.

77. The method of claim 74 wherein the polishing pad is a first polishing pad and the frictional force is a first frictional force, further comprising:

applying a force to a second polishing pad via the conditioning body;

moving at least one of the second polishing pad and the conditioning body relative to the other of the second polishing pad and the conditioning body;

detecting a second frictional force of the second polishing pad on the conditioning body in a plane of the planarizing surface; and

comparing the first and second frictional forces.

78. A method for conditioning a planarizing medium used for planarizing a semiconductor substrate, the method comprising:

engaging a conditioning body with the planarizing medium;

moving at least one of the conditioning body and the planarizing medium relative to the other of the conditioning body and the planarizing medium to remove material from the planarizing medium; and

maintaining an approximately constant frictional force between the conditioning body and the planarizing medium by adjusting a relative velocity between the conditioning body and the planarizing medium.

79. The method of claim 78 wherein maintaining an approximately constant frictional force includes selecting a target frictional force, detecting a force between the conditioning body and the planarizing medium and adjusting the relative velocity until the force is approximately equal to the target frictional force.

80. The method of claim 79 wherein moving at least one of the conditioning body and the planarizing medium includes rotating the planarizing medium relative to the conditioning body.

81. The method of claim 79 wherein the conditioning body is coupled to a support member for supporting the conditioning body relative to the planarizing

medium, further wherein detecting the force includes measuring a force transmitted to the support member by the conditioning body.

82. The method of claim 81 wherein the support member includes a generally upwardly extending portion coupled to the conditioning body and a generally laterally extending portion pivotably coupled to the upwardly extending portion, further wherein detecting the force includes detecting a force between the upwardly extending portion and the laterally extending portion with a force sensor.

83. The method of claim 81 wherein detecting the force includes detecting a deflection of the support member.

84. The method of claim 81 wherein the support member includes a piston slidably received in a cylinder and detecting the force includes detecting a movement of one of the piston and the cylinder relative to the other of the piston and the cylinder.